

# TDC Coordination

## Insights from 2018 International Assessment

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February 12, 2019

# **Customer to Distribution Coordination**

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## C-D Coordination requires robust cyber-physical integration

Cyber-physical integration is the information, controls and communications required to scale the interconnection and utilization of DER (and increasing number of nodes).

- The need for improved observability and related information necessary for planning and operations,
- Standards harmonization and commercial maturity to achieve desired interoperability and performance to enable the scale desired, and
- Robust communications with integral security to satisfy the availability, reliability and other performance requirements for system operations.

***AEIC & CIGRE Joint Working Group C2/C6.36 reports identify similar issues regarding, visibility, controllability, and security***

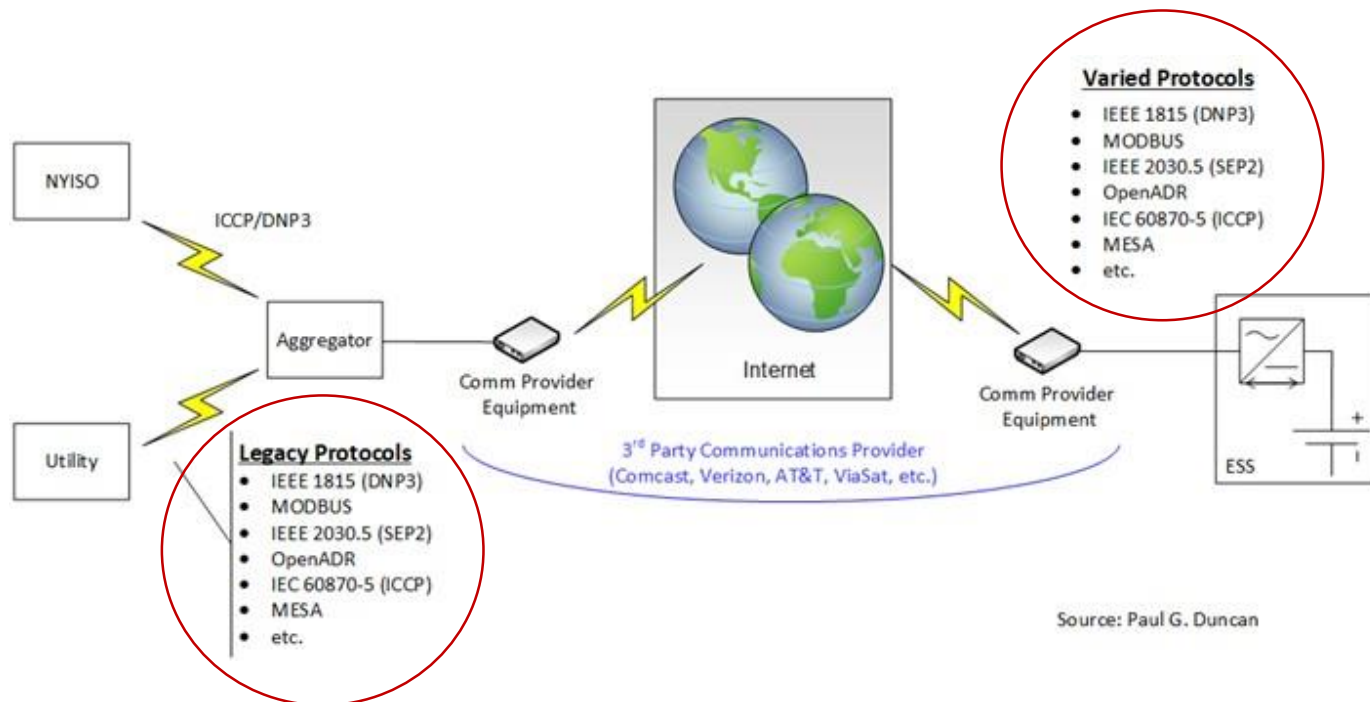
# AEIC DER Utilization Findings

[https://www.pge.com/pge\\_global/common/pdfs/about-pge/environment/what-we-are-doing/electric-program-investment-charge/Joint-IOU-SI-White-Paper.pdf](https://www.pge.com/pge_global/common/pdfs/about-pge/environment/what-we-are-doing/electric-program-investment-charge/Joint-IOU-SI-White-Paper.pdf)

- Standardization of communication and operational procedures is necessary between utilities and DER providers to ensure instructions are received, interpreted and executed consistently by different aggregators.
- Smart Inverter-enabled DERs and their data must be visible and available to the utility and/or aggregator for these resources to be fully utilized by the Distribution Operator.
- IOU demonstration experience suggests communications to DER assets requires additional research, development and demonstration.
- The management systems and communication infrastructure used to integrate DERs are as critical as the DERs themselves and must have reliability and redundancy comparable to traditional utility “wires” infrastructure.
- Phased implementation of standards for advanced Smart Inverter functions has created complexity for manufacturers in getting Rule 21-compliant Smart Inverters to market and for Nationally Recognized Testing Laboratories (NRTLs) to certify and test Smart Inverters.
- Cybersecurity standards need to be adopted by the industry and integrated into relevant communication standards for Smart Inverter interconnection. Existing methods to ensure end-to-end cybersecurity between the utility and Smart Inverter-enabled DERs need significant improvement.
- Utility operational capabilities and systems that automatically analyze grid conditions, determine optimized solutions, and communicate signals to aggregators and DER assets are needed to enhance the value of DERs to the grid.

# Standards Harmonization Needed

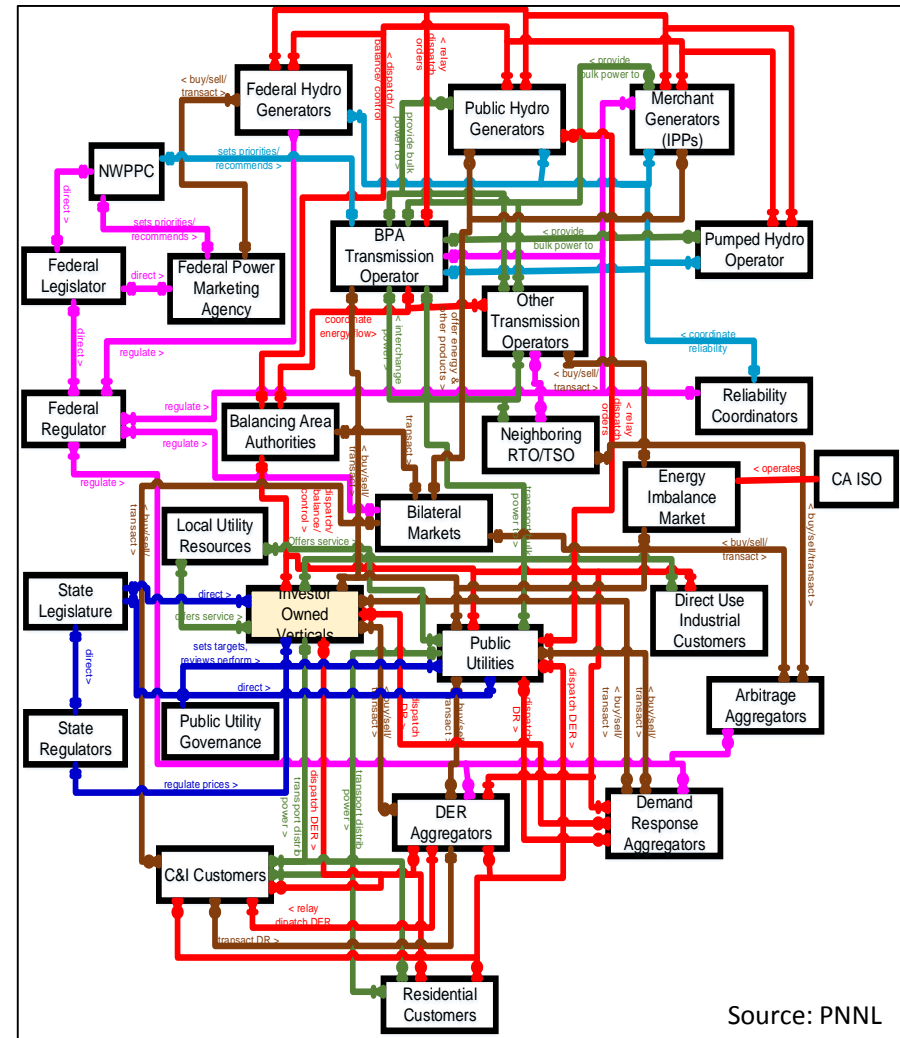
Lack of harmonization on the DSO and DER provider/equipment standards creates significant integration and operational issues leading to significant risks – note that ISO interface doesn't have this issue.



# **Distribution to Transmission Coordination**

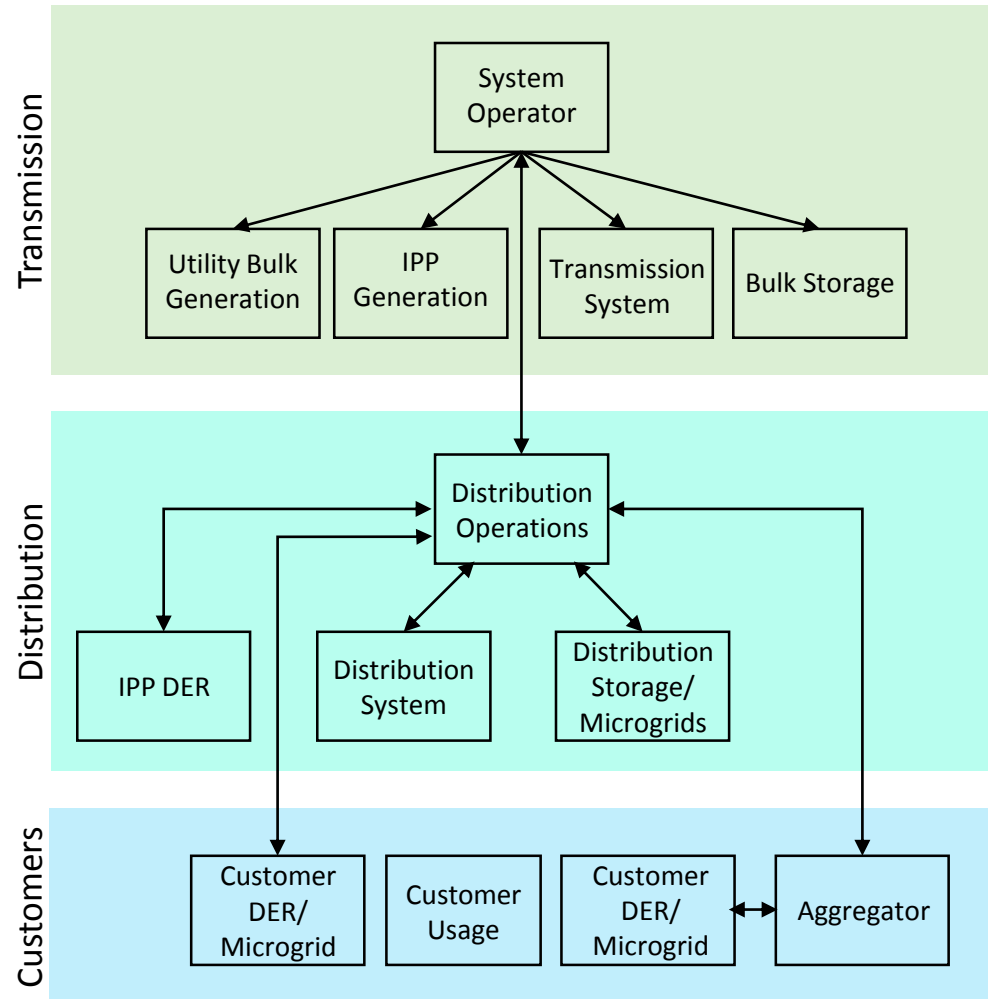
# The Grid Has Complex Legacy Structure

- Industry structure is the context within which modernization changes are being made
- Structure has been partly planned and partly grew organically
- Changing requirements and external forces are impacting existing structure



# Coordination Framework Skeleton Diagram

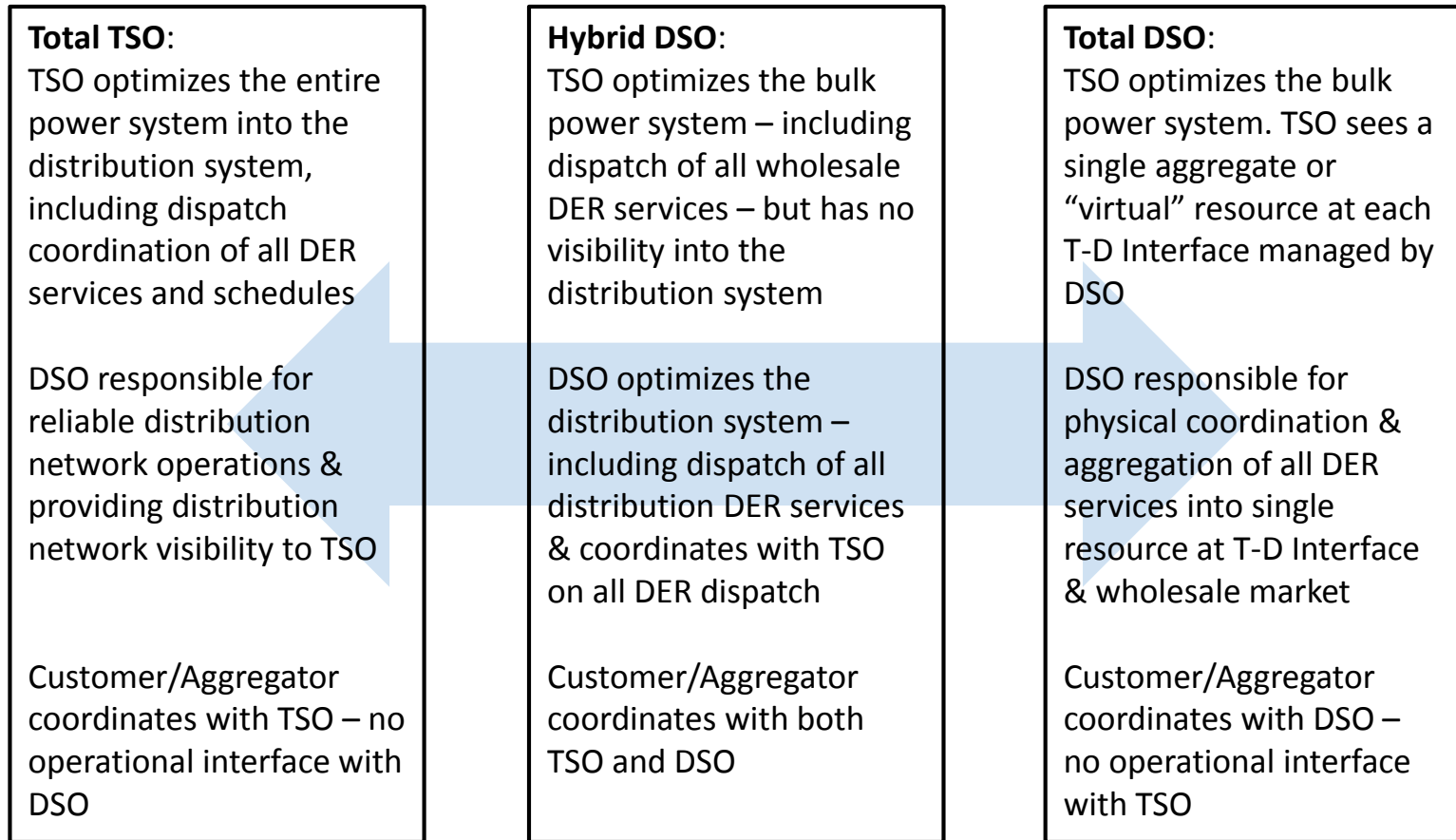
- Derives from Complex Industry Structure Diagram
- Focuses on key issues to address (e.g., architectural principles)
- Indicates flow of coordination
- Use layered decomposition model (i.e. Laminar Framework) as basis for the diagrams and analysis





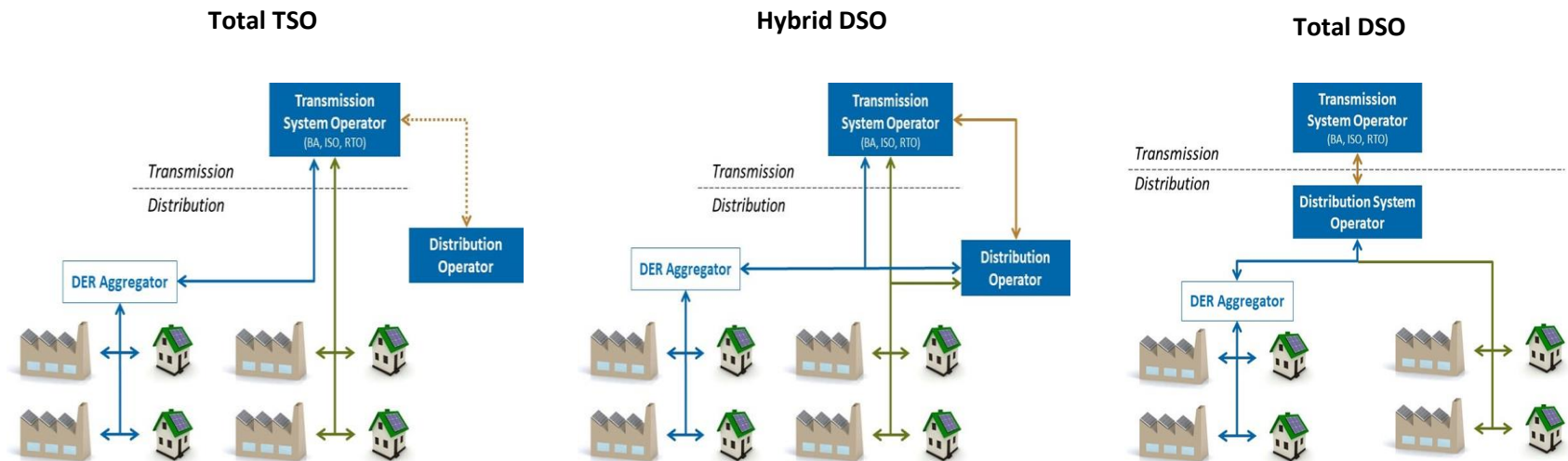
# Integrated System Operations Evolution

A spectrum of possible designs can be envisioned in terms of the complementary roles of DSO and TSO at the T-D interface.




# Simple Diagrams for Reference Models

3 Reference coordination models are depicted simply in these skeletal diagrams – in practice they are more complex



# Architectural Principles

(Subset of architectural principles for TSO-DSO Coordination)

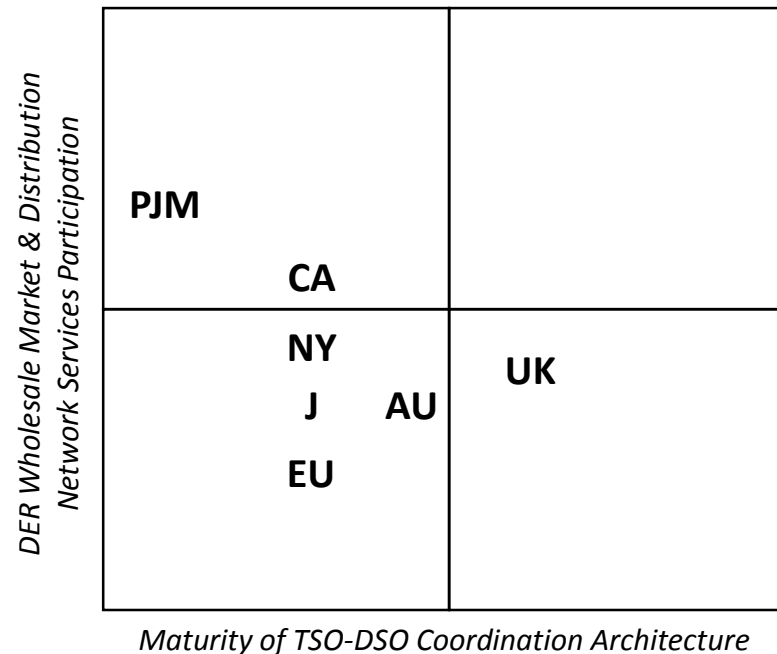


Principle	Description
Observability	Function related to operational visibility of the distribution network and integrated DER. Sufficient sensing and data collection can help to assemble an adequate view of system behavior for control and grid management purposes, thus providing desirable snapshots of grid state. The data can also be utilized to validate planning models. Observability needs of DSO and TSO depend on how the coordination framework is specified.
Scalability	Ability of system's processes and technology design to work well for very large quantities of DER resources. Coordination architecture can enhance or detract from this desired capability.
Cyber security vulnerability	While this topic has many dimensions, the principle here is to reduce cyber vulnerability through architectural structure. Structure can expose bulk energy systems to more or less vulnerability depending on data flow structure, which depends on coordination framework. To be minimized.
Layered decomposition	Layered decomposition solves large-scale optimization problems by decomposing the problem multiple times into sub-problems that work in combination to solve the original problem. Used here as the basis for comparing grid architectures.
Tier bypassing	Creation of information flow or instruction/dispatch/control paths that skip around a tier of the power system hierarchy, thus opening the possibility for creating operational problems. To be avoided.
Hidden coupling	Two or more controls with partial views of grid state operating separately according to individual goals and constraints; such as simultaneous, but conflicting signals DER from both the DSO and TSO. To be avoided.
Latency cascading	Creation of potentially excessive latencies in information flows due to the cascading of systems and organizations through which the data must flow serially. To be minimized.

Source: PNNL

# 2018 International TSO-DSO Comparative Assessment

Primary and secondary research supporting comparative assessment of TSO-DSO development efforts in 8 regions/countries for AEMO



UK & AU have the most sophisticated approaches and analysis conducted to-date. But, are hampered by a strong institutional and stakeholder bias towards real-time centralized markets despite the significant operational issues.

# UK Coordination Models

## Current & Future Models Under Discussion

- UK Open Networks initiative evaluating alternative TSO-DSO Coordination Models
- 5 Future Models have been identified and under evaluation  
<http://www.energynetworks.org/electricity/futures/open-networks-project/>

### Example Grid Architectural Analysis:

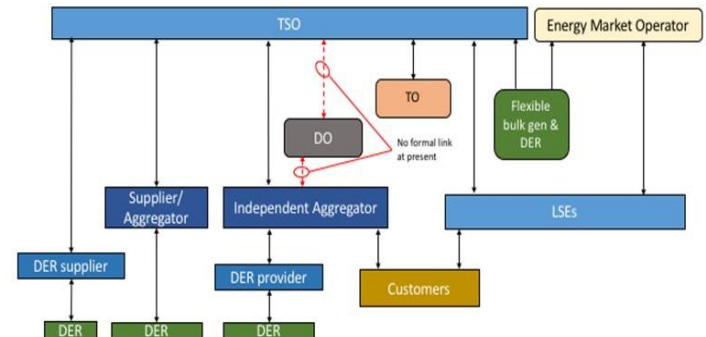
UK Option 2, the responsibility for DER coordination is shared by the DSO and TSO, leading to a more complicated arrangement involving these parties and the aggregators, although the sharing mechanism is not clear.

This model is somewhat similar to the Total DSO model, but the sharing arrangement results in a blending of roles that will require extra coordination to perform.

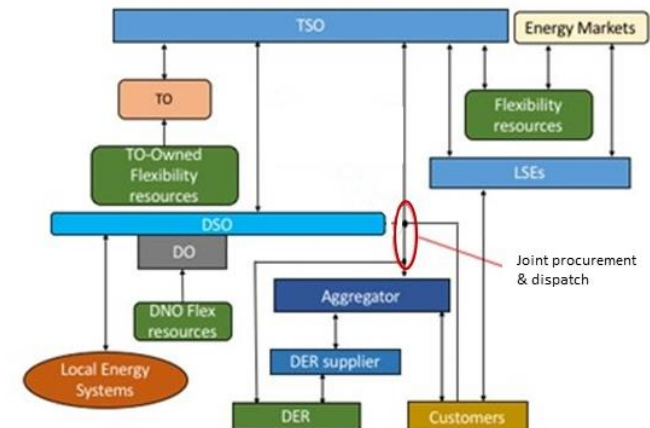
Option 2 partially **degrades the layered decomposition** structure and allows for **some tier bypassing**, although the proposed function-sharing (“joint procurement and activation”) may prevent that from being an issue. This structure **increases the coupling** between the TSO and DSO (not hidden in this case), since the DSO cannot manage the DER in its service area alone while interfacing to the TSO in a modular fashion.

The joint arrangement results in **data flow complexity** involving the DSO, the TSO, the aggregators, the customers, and DER. This is a result of the structure shown in the red oval which comes about due to the definition of **joint roles instead of clean separation of functions**.

UK Current (Centralized Procurement & Dispatch)



UK Future 2 (Joint Procurement & Dispatch)



# NY Coordination Models

## Current & Future Models Under Discussion

### Example Grid Architectural Analysis:

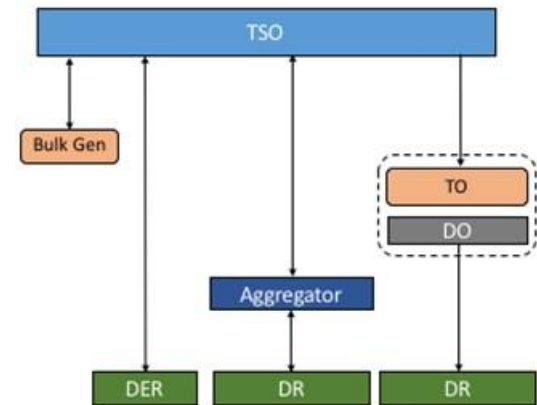
Future 2, the removal of the link between the aggregator and the TSO creates **some of the layered decomposition** structure by **eliminating one source of tier bypassing**, but the presence of a link from DER to the TSO **still allows for tier bypassing, hidden coupling, scalability issues, and cyber vulnerability** at the TSO level.

Future 2, the DSP is potentially somewhat better able to manage the DER, and if coordination between TSO and DSP is well organized, the **tier bypassing problem may be mitigated**.

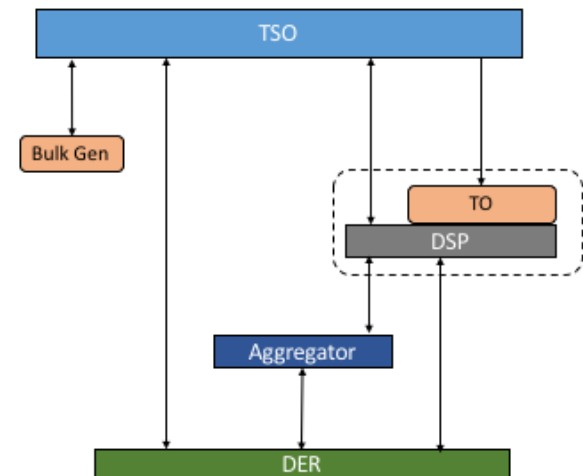
If some **DER are bidding into the wholesale markets and some into a DSP market**, for example, then the **potential for mis-coordination exists**.

The potential **ability of aggregators to participate at the TSO level is eliminated** in this model that **reduces tier bypassing**. However, it **does not eliminate tier bypassing** as some DERs can still bypass. The **hidden coupling problem remains** but likely at a low level.

New York Current



NYISO Proposed Future 2



# CA Coordination Models

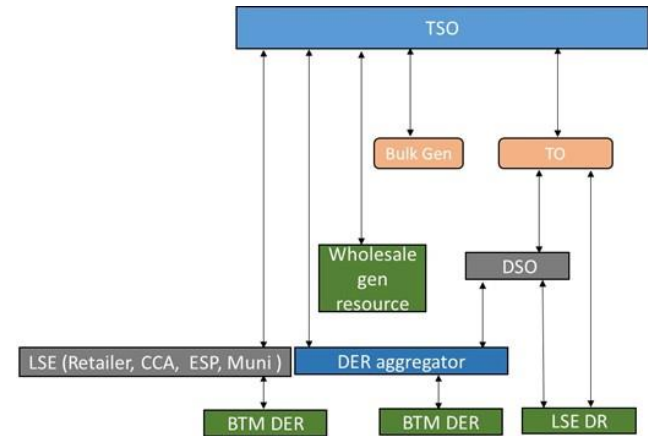
## Prior & Future Models Under Discussion

### Example Grid Architectural Analysis:

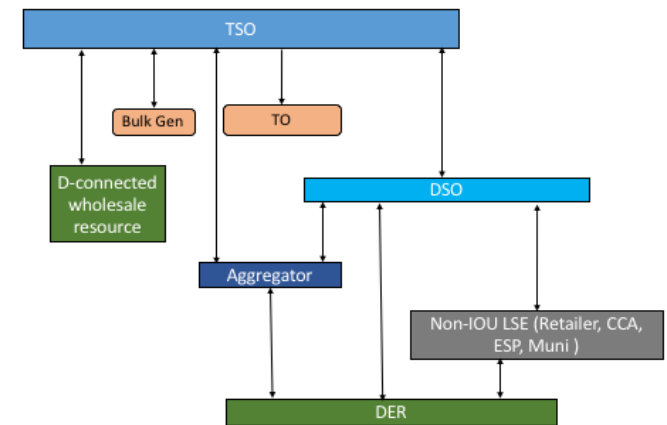
The previous California structure reflects DER services provided directly to the TSO as well as the existing demand response (DR) programs that distribution utilities operate for the benefit of wholesale market operations. The resulting complexity involves a large number of entities and a somewhat **ad hoc coordination structure**. Note there are **no coordination links between the CAISO (TSO) and the DSO**.

A future **Hybrid DSO based model**, may be politically feasible in near-term. A hybrid model will **continue to exhibit tier bypassing** due to the path from DER to aggregator to TSO that bypasses the DSO. In addition, the potential for **hidden coupling exists, with some aggregators, LSEs and the DSO all connecting to DERs** unless some coordination mechanism is worked out. The presence of the direct aggregator-to-TSO connection also presents a moderate cyber vulnerability to the bulk energy system.

California Prior



California Future



# Takeaways

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- Theme 1: Customer DER to distribution interconnection standardization and operational integration technology maturity for the provision of services is currently inadequate.
- Theme 2: The current DER coordination models for all locations exhibit considerable distribution operator bypassing, with the attendant issues of hidden coupling and cyber vulnerability.
- Theme 3: The present and future models involve two schools of thought regarding coordination structure: 1) a centralized approach where the TSO performs all coordination, and 2) layered approaches where a DSO has a significant role in coordination.